Pollution in Lake Albert with special reference to heavy metals

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1. Background

As human population and demand for resources ~~are on the increase~~, the related economic activities such as mining, commercial farming (with use of pesticides and fertilisers), construction, transportation and others, are as well mushrooming. In most African countries, including Uganda, studies on environmental pollution, especially by heavy metals has not been given a priority and yet currently it forms one of the major environmental problems in the world. Just as nutrients like phosphorus and nitrogen get enriched into a water body, other contaminants such as heavy metals may enter and accumulate in similar environment, moreover unnoticed, and may pose toxic problems to the aquatic life and the entire food chain. Heavy metals like copper and zinc are essential for growth and well being of living organisms including human beings but the organisms may suffer their toxic effects once they are in excess (pollution).

Aquatic ecosystems are highly susceptible to this type pollution because they are the final recipients of a number of discharges and run offs from the catchment and other related wastes. The major routes of heavy metal uptake by human beings are food, water and air and since a lake such as Lake Albert provides both water and food resources (e.g. fish) to the riparian communities and other beneficiaries, the likely dangers from such pollutants can not be ruled out. Lake Albert is currently facing a number of upcoming economic activities, including the oil exploration within its basin, and these can lead to this kind of pollution of this aquatic ecosystem. Although some investigations have been done on status of heavy metal in Lake Albert (e.g. DWD, 1998) and sediments (NaFIRRI 2007; 2008), they have been on limited scope especially in terms of lake portions covered.

Information on the sources, concentration levels (e.g. in lake sediments and water) and distribution of the heavy metals in the entire lake environment, is paramount if mitigation measures towards such kind of pollution and overall sustainability of the lake as a resource, is to be achieved. The purpose of this study conducted from January 2007 to April 2008, by NaFIRRI, was to investigate specifically the status of heavy metal (copper, Cu; Zinc, Zn and Lead, Pb) concentrations in bottom sediments of Lake Albert and relate the information to the safety of Lake environment and its entire fisheries.

2. Methodology

2.1 Study area

The study was conducted on lakewide basis, covering south, central and north of the lake, while paying attention to specific habitat zones such as bays/lagoons, river inlets, inshore and offshore waters, for a comparison. The sampling was also done during different quarters of year to cater for seasonality effects.

2.2 Sampling and analyses

Standard methods were followed for both sampling and analyses of sediments for the selected heavy metals. Three composite sediment samples were collected using a petite Ponar grab. Sediments were thoroughly stirred for homogeneity and a portion (~250 g) was taken for analysis. Analyses for the metals (Copper, Cu; Zinc, Zn; Lead; Pb, and Iron (Fe) as other metal, were done following specified methods (APHA 1992, Kruis 2005).

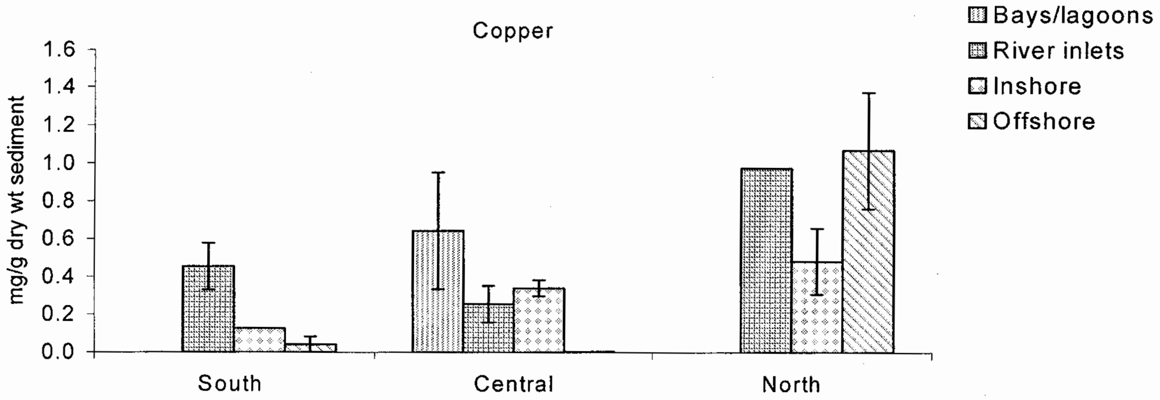
3. Results

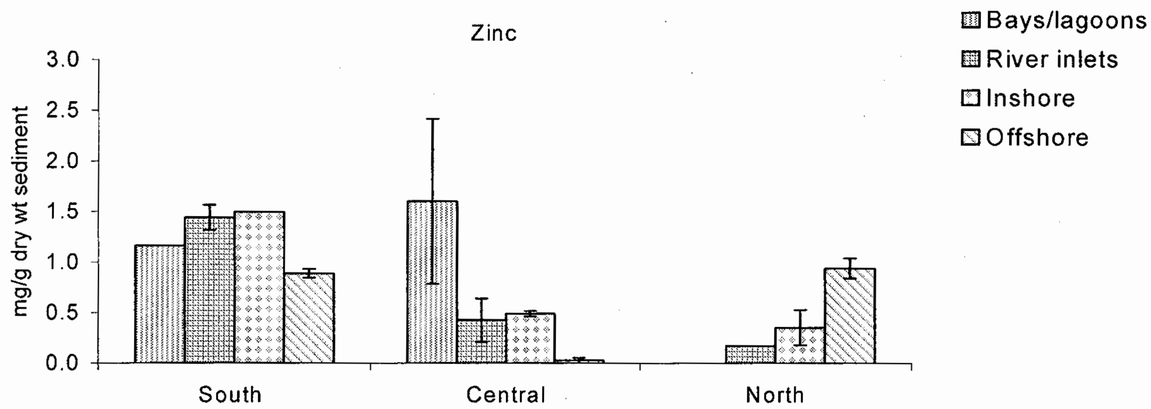
The mean concentrations of the selected heavy metals in sediments of Lake Albert are shown (Fig. 3.1). In the south, the mean concentrations of Cu in mg/g dry weight sediment, range from 0.0 at the bays/lagoons and offshore areas to about 0.5 at the river inlets. The value of the same metal (Cu) in central portion, is highest (0.6 mg/g) at the lagoon (Ngassa lagoon), followed by inshore and river inlets (0.3 mg/g) and lowest at offshore (0.01 mg/g). The concentrations of Cu in the north, are generally higher than those in the central and south, with values ranging from about 0.5 to 1.1within river inlets, inshore and offshore areas. In the south, the mean concentrations of Cu in mg/g dry weight sediment, range from 0.0 at the bays/lagoons and offshore areas to about 0.5 at the river inlets. The value of the same metal (Cu) in central portion, is highest (0.6 mg/g) at the lagoon (Ngassa lagoon), followed by inshore and river inlets (0.3 mg/g) and lowest at offshore (0.01 mg/g). Concentrations of Cu (0.5-1.1) seen within river inlets, inshore and offshore areas in the north are generally higher than those in the central and south, thus showing an increasing trend from south to north.

Zinc (Zn) is relatively more abundant (0.9-1.5 mg/g) and uniform in the sediments of the south than those of central and north with values ranging from about 0.01 to 0.9 mg/g. The lagoon (Ngassa) in central portion is an exception in that it has both high mean value (1.6 mg/g) and variability of Zn concentration as compared to all others in the lake. Lead concentrations in the sediments of all the sites are generally very low as compared to Cu and Zn. Apart from particular sites such as river inlets and inshore sites of the south which show values of about 0.1 to 0.3 mg/g, Pb was not detected from sediments from all the three portions of the lake. The concentrations of Fe in sediments (not shown on graph) as compared to those of Cu, Zn and Pb are very high in all the sites. Most of sites have mean values of Fe concentrations ranging from about 226 to 583 mg/g dry wt sediment.

4. Discussion

Although different compartments namely water, biota and sediments can be investigated for heavy metals, sediments were given first priority during this study because they can present a clearer indication of metal inputs and accumulation in aquatic environments, as explained in the review of other similar studies (Biney *et al.*, 1994). Relatively higher values of Cu at river inlets than at other sites, in the south, show that the rivers such as Muzizi and Nkusi, contribute to input of this metal into the





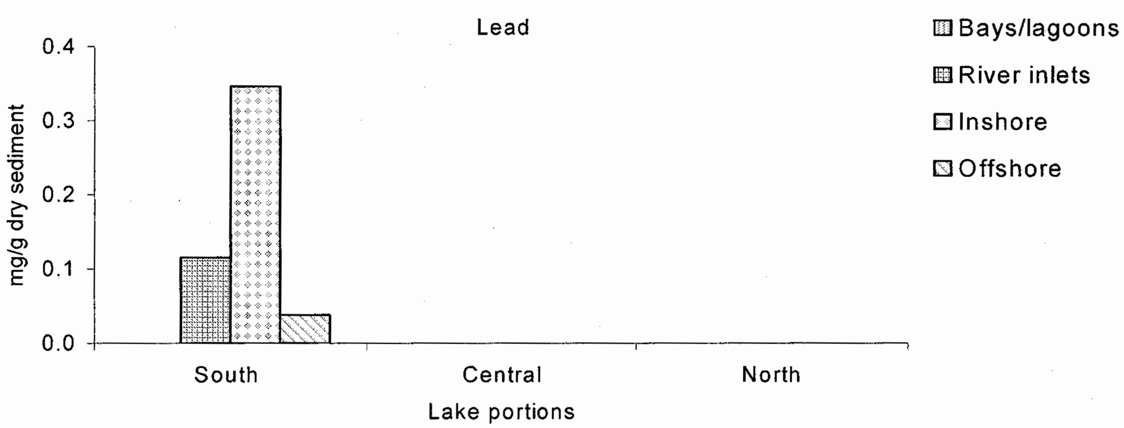


Fig. 3.1. Heavy metal concentrations in sediments (mean ± SE) of Lake Albert.

lake. However, this input by the rivers in the south is likely to be more of natural e.g. weathering of the rocks than anthropogenic. Higher concentration of Cu within the Bays/lagoon (Ngassa lagoon) than in other sites in central portion of the lake is due to its isolation from the main lake, enclosure and poor flushing effect. The increasing trend in concentrations of Cu from south towards northern portion of the lake is probable indications that anthropogenic activities associated with such metal in the catchment and its subsequent entry into the lake e.g. through rivers, also increase in the same direction but may not be significant. It is also likely that there are differences in composition of such metals in the rocks and soils surrounding the lake at the specific three portions mentioned. The concentrations of Cu in the sediments of this lake, has also been reported (NaFIRRI, 2007) to be correlated with amount of organic matter, which could have also varied from portion to portion of the lake. In comparison, the present concentrations of Cu in the lake sediments are significantly (x10) higher than those reported during a recent survey on the lake (NaFIRRI, 2007). This could be mainly due to some differences in the analytical methods.

The abundance and distribution pattern of zinc in the three lake portions could as well be attributed to differences in their composition in the lake sediments at the these particular lake portions and also the distribution factors e.g. river flows that seem to be more pronounced in the extreme south. The significant concentration of Zn at the Ngassa lagoon shows that such a metal enters and is trapped due to the enclosed structure of the lagoon and poor flushing effect, as explained for Cu above. This status of Cu and Zn in Ngassa lagoon indicates that such metals and other pollutants from the surrounding e.g. fish landing sites, enter the lake from time to time and just get widely distributed in the sediments. The organisms, including fish in such a lagoon are at risk of accumulating such metals and may pose toxic problems to the final consumers such human beings. The significantly low to undetected levels of Pb in the sediments in the entire lake is probably due to very minimal loadings into the system and this stands as an advantage to aquatic organisms in terms of its toxicity. In other studies as reported by Wetzel (2001), Pb is known to be toxic to aquatic organisms at low levels and much of its loadings to the basins, is through combustion of fossil fuels and deposition especially by atmospheric means. It is likely that the present concentrations of Pb in the lake sediments are more at background levels than being influenced by anthropogenic activities.

Although the present concentrations of metals such as Cu and Zn appears to be elevated at particular sites e.g. Cu in the northern portion of the lake, they may not be a threat to the lake ecosystem. Based on explanation for situation in the nearby Lake Edward (Bugenyi and Lutalo-Bosa 1990), and other studies on freshwaters (Wetzel, 2001), the present concentration levels of Cu and Zn in Lake Albert, may not pose any toxic effects to aquatic organisms such as fish. As it was found in Lake Edward, Lake Albert also seem to have sufficient dissolved species, that can impart ionic interference to heavy metal such as Cu^{2+} and thus reduce its ionic concentration and possible toxic effects on the organisms. High concentrations of Fe in the lake and the likely presence of adequate dissolved organics especially from algae, react with copper ions (Cu^{2+}) to form precipitate and thus reducing its ionic content in the system. This hypothesis concurs with findings of the previous survey on the lake (DWD, 1998) in which the concentrations of Cu and Zn in the waters around Butiaba, were in most cases not detected (0.0 μg/L) and therefore, such levels were normal for the lake and even within requirements for drinking water. However, further investigation to determine the ionic status and possible toxic effects by the listed metals in the lake environment other than only their total concentrations as was done in the present study could be of relevance.

5. Conclusions

i. Heavy metal (copper, zinc and lead) pollution is currently not a threat to the environment and the fisheries of Lake Albert but may worsen with increasing anthropogenic activities;

ii. Relatively high concentrations of metals such as copper and zinc in the sediments at the isolated and enclosed sites (lagoons), indicate that the catchment can contribute to entry of such contaminants into the lake;

6. Recommendations

i. Continued monitoring of heavy metal and other pollution in the lake is paramount, to trigger the necessary management measures;

ii. Holistic approach for developing mitigation measures against the likely increasing heavy metal and other pollution could be of relevance;

iii. Environmental Impact Assessment (EIA) to be involved when establishing any economic activity e.g. mining, factories and farms within the lake basin;

iv. Further investigation to determine the ionic status and possible toxic effects by the listed metals in the lake environment other than considering only their total concentrations in the sediments.

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